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The Soviet Energy Plight: Runaway Investment or Energy Shortfalls

An Intelligence Assessment

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The Soviet Energy Plight: Runaway Investment or Energy Shortfalls

An Intelligence Assessment

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**The Soviet Energy Plight:
Runaway Investment or
Energy Shortfalls**

Key Judgments

*Information available
as of 15 December 1988
was used in this report.*

Despite rapidly rising costs of energy production and the need to boost energy exports, the Soviet economy remains addicted to energy. Vast and heretofore easily exploitable energy resources have firmly embedded the impression of cheap, plentiful energy in the minds of Soviet energy consumers. Waste remains pervasive in both factories and households. If our estimates hold true, energy-associated problems will ultimately become a major barrier to the sustained economic growth that Gorbachev wants and badly needs.

The Soviet Union has become the world's largest producer of energy, but costs of energy production have accelerated over the last decade. More important, the share of total investment going to energy would have to more than double should Moscow pursue current energy policies to boost energy output about 40 percent by the year 2000:

- Maintaining oil production will be increasingly costly because new fields are deeper, less productive, geologically more complex, or in distant areas with more severe environments.
- Natural gas has excellent prospects for growth, but maintaining this growth will depend on expanding the gas pipeline network and gas storage facilities, and on converting customers from oil to gas.
- Utilizing coal reserves in the eastern USSR requires sizable investment to develop and implement technology for using low-quality coal and transmitting power over long distances.
- Getting the nuclear program back on track in the wake of the Chernobyl¹ accident requires increased spending on safety and an intensive public education effort to regain acceptance of nuclear energy.

If energy were to soak up a growing share of investment resources, Gorbachev's modernization and consumer welfare goals would be out of reach. Energy shortages stemming from a failure to meet production targets, however, would be equally devastating to regime growth objectives.

The Soviet Union is severely hampered in its ability to dodge this "investment bullet" by emulating the gains in energy efficiency that have characterized Western experience since the oil shock in 1973. Doing so would require substantially higher energy prices that reflect changing demand and extraction costs, along with radical changes in the economic system to ensure that these prices lead to energy conservation:

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- Gorbachev's reform program will probably not proceed far enough to provide incentives for energy conservation in the early 1990s; in any event, the regime can ill afford the degree and nature of economic disruptions experienced by the West in its transition to higher priced energy.
- Meeting conservation needs also would require the development of new industry to manufacture energy monitoring and regulating equipment, as well as a long-term investment program to retool industry with more efficient machinery.

We expect Moscow to reformulate its energy policies as the inexorable nature of the investment burden becomes clear. We believe that Gorbachev—drawing from a growing consensus among his energy experts—will endorse the following initiatives to limit the rise in the share of investment going to energy, while sustaining growth in energy production:

- Allow oil output to decline somewhat while continuing to boost natural gas production.
- Postpone large increases in coal output while concentrating on solving technical problems of transporting and burning low-quality coal.
- Reestablish a consensus that nuclear energy is safe and reliable and move ahead nuclear power plant construction.
- Stress energy conservation, but stop short of implementing the necessary measures to produce substantial gains.

The regime may hope to keep its modernization and consumer welfare goals on track and still meet the increase in investment required for this revised program. Even if everything goes as planned—a highly unlikely event—sustaining a production-oriented approach to energy policy would be inadequate. Moscow would have insufficient energy in the 1990s to support Gorbachev's economic goals:

- Unless there are major improvements in energy efficiency, the USSR will be hard pressed to support more than a 2-percent average rate of economic growth over the period—far short of Gorbachev's 5-percent target.
- Addressing this domestic shortfall by cutting oil exports would undermine the economic foundation of Soviet trade with Eastern Europe and severely crimp Moscow's ability to import from the West.

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Barring a large oil discovery that could be easily tapped or a sharp increase in world energy prices—each highly unlikely—the Soviets face an energy dilemma in the 1990s. They will probably pursue a series of half measures to make the best of a bad situation:

- Tight energy supplies will probably force some rationing and require occasional curtailment of deliveries to key customers—including Eastern Europe. The shortfalls, moreover, will worsen if safety and environmental concerns further disrupt the nuclear and coal programs, if the gas distribution system does not expand as quickly as planned, or if oil production declines more rapidly than we anticipate.
- Moscow will try to diminish oil's share of Soviet exports by offering more gas and by trying to step up nonenergy exports. Only small gains are likely, because Moscow confronts limited markets for its products and the danger of destabilizing oil-dependent client states.
- Moscow will probably seek increased imports of Western equipment to support oil extraction, gas distribution, and energy conservation. Such imports, of course, will strain already tight hard currency reserves.

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Scope Note

This paper assesses prospects for the USSR's energy supply in the 1990s, analyzes shortcomings of Moscow's Long-Term Energy Program, and projects probable new initiatives in energy policy. It relies on previous in-depth studies on Soviet energy production, conservation, investment, and demand:

- DI Research Paper GI 86-10074X/SOV 86-10049X
November 1986, *Arctic Petroleum Development: Western Capabilities and Soviet Needs.*
- DI Research Paper SOV 87-10032X
June 1987, *The Soviet Nuclear Power Program After the Chernobyl' Accident.*
- DI Research Paper SOV 88-10035
August 1988, *USSR: Natural Gas—Fuel for the 1990s.*

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Soviet Energy Plight: Runaway Investment or Energy Shortfalls

The Soviet Economy: Addicted to Energy

The Soviet economy is a glutton for energy. The Soviets require about one unit of standard fuel to produce the equivalent of \$1 in national product.¹ Comparable figures for the US and Japanese economies are, respectively, 0.8 and 0.4 unit of standard fuel. Some of the difference can be explained by the harsh, cold Soviet climate, which increases heating costs. Some can be explained by the dominance of energy-intensive heavy industry, accounting for 35 percent of national output as compared with roughly 12 percent in the US economy.² But most of the difference can be explained by the Soviet economic system, which fails to reflect the true opportunity (full) cost of energy resources, thereby encouraging grossly uneconomic production and consumption.

The Soviets have relied on massive exploitation of their vast energy wealth to sustain economic growth at home and, increasingly, in their client states. Until the late 1970s, Moscow was encouraged by successive discoveries of easily accessible energy deposits, inducing it to set low energy prices. This price policy, coupled with rapidly rising energy production during the last 20 years, has created and sustained an impression of cheap, plentiful energy in the minds of Soviet energy consumers.

¹ To eliminate the variation in energy value of fuels and primary electricity, we measure energy in units of standard fuel equivalent and barrels per day (b/d) of oil equivalent. The standard fuel equivalent is equal to 7 million kilocalories per metric ton. Soviet oil production and consumption data have been converted to b/d notation using the relationship of 7.3 barrels per metric ton. Accordingly, annual production of 1 million tons SF equals 0.7 million tons of oil, or 14,000 b/d. Also in 1987 the energy value of 1 million tons of Soviet oil (20,000 b/d) equaled 1.24 billion cubic meters of gas or 2.36 million tons of raw coal.

² In the USSR, industry—including transportation, but excluding electric power—accounts for about two-thirds of domestic energy use. Within the industrial sector, a few industries dominate energy consumption—ferrous metallurgy (11 percent), machine building and metalworking (MBMW) (8 percent), petroleum refining and petrochemicals (7 percent), and chemical (7 percent).

Thus, unlike Western economies, the Soviet economy has not provided incentives to encourage households and enterprises to conserve energy through improvements in management, work habits, and small-scale expenditures on insulation and equipment.

During the 1960s and 1970s, the Soviets saw little need to raise prices because price signals from world markets that energy was becoming more costly did not reflect the experience of the domestic energy industry. Indeed, the Soviet press blamed the "oil monopolies" and Western consumerism for the energy price hikes and boasted that steady energy prices in the USSR were a result of a superior economic system.

When it became clear in the late 1970s that Soviet energy production costs were rising, the centrally planned economic system proved unable to direct efficient decisions on the choice of alternative fuels for development or to encourage energy conservation. Energy production ministries receive investment resources on the basis of prior allocations and on what it takes to meet production targets—not in relation to production costs. Planners have felt little pressure to reduce the inflated "norms"—the amount of energy required to produce a unit of output—that govern energy allocations to industrial enterprises. Enterprise managers do not want to jeopardize fulfillment of their plan targets by cutting energy use. They pay low, subsidized, and generally fixed prices for energy; incur only small fines—usually uncollected—for consumption that exceeds allotments; and can readily pass on the higher energy costs by raising the prices of their final products. One manager interviewed recently in the Soviet press reported that natural gas supplies accounted for only 1.5 percent of his plant's operating cost and claimed that even a fourfold price increase would not cause much of a change in the attitude toward saving energy (figure 1). Soviet leaders and the press regularly exhort industries and citizens to use energy efficiently, but waste is pervasive (see inset on page 4).

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The Transition to Energy Efficiency

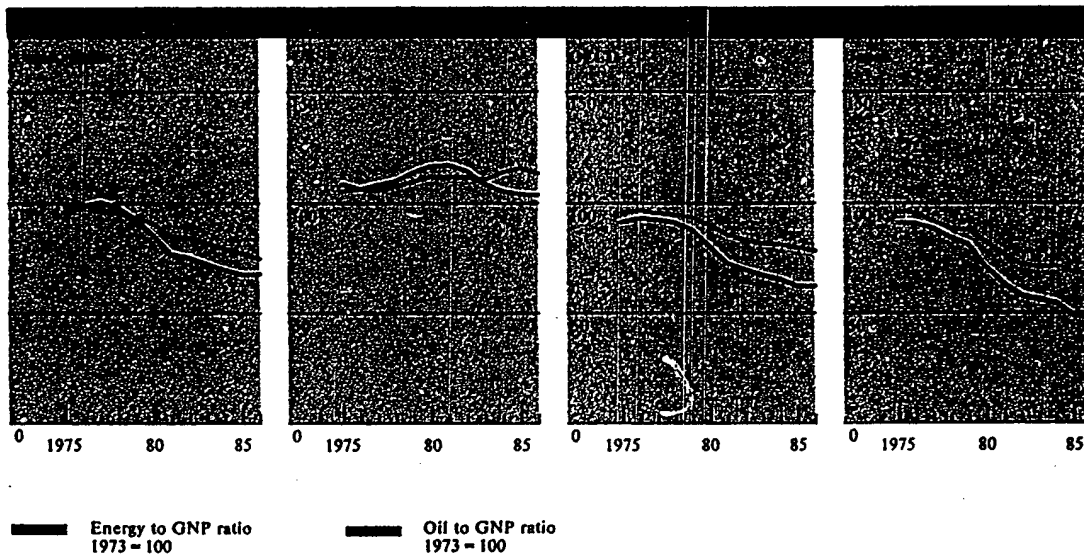
After the oil price shock of 1973, Western economies underwent several years of painful adjustments before energy efficiency improved substantially. Developing energy-saving products and redesigning industrial equipment was a slow process.

During the transition period, higher energy prices and shortages of energy adversely affected the economies of many industrialized nations:

- Higher energy prices—for example, a 60- to 70-percent boost in gasoline prices—contributed to inflation.

- Initially, some firms closed or reduced business hours and shifted work to night hours to take advantage of cheaper electricity.
- Economic growth in some Western countries was negative or less than 1 percent during 1973-75, in part because of energy shortages

The Soviets are confronted with prospects of a similar transition period.



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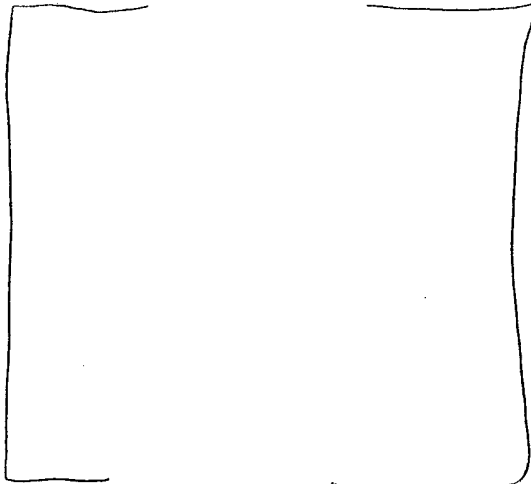


Figure 1. Soviet cartoon satirizing plant managers' negligent attitude toward energy conservation.

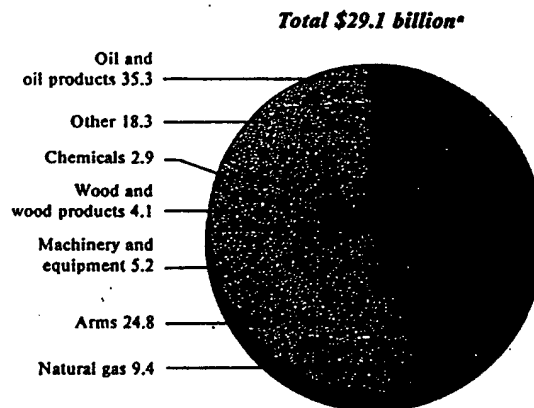
Energy use in relation to gross national product has not improved since the mid-1970s and, indeed, took a turn for the worse in the early 1980s. Soviet energy experts claimed that 1986 marked the end of the economy's addiction to energy because demand grew less than 2 percent while the economy showed a healthy expansion. Much of the economic growth, however, was accounted for by increased agricultural production, sustained by better weather, not by increased energy efficiency. The celebration was short lived because in 1987 energy demand increased by 3.1 percent while the economy languished. If energy use were to continue to grow proportionate with the economy, Gorbachev would have to increase domestic energy supplies 65 percent by the year 2000 to meet his goal of 5-percent annual economic growth.

Cheap Soviet energy and strong world demand also encouraged Soviet reliance on energy as a source of hard currency earnings and to cement relations with economically weak client states. In the 1960s and 1970s, net energy exports grew by almost 10 percent annually:

- Oil remains the linchpin of Soviet trade with the West, accounting for about one-half of the value of total exports for hard currency through most of the

Figure 2
USSR: Hard Currency Exports, 1987

Percent



* Current US dollars.

1980s.¹ Soviet natural gas exports to the West have increased 50 percent in volume since 1980, providing \$2.7 billion in revenues in 1987.² The collapse in world oil prices in early 1986 undermined Moscow's earnings, but energy remains a cornerstone of hard currency trade (figure 2).

¹ Moscow's ability to maintain its oil export commitments is aided by deliveries of Middle East oil, obtained mostly in exchange for Soviet arms. Moscow currently makes about 5 percent of its hard currency oil sales from this source—overall, reexported oil comprises about 10 percent of total Soviet oil exports.

² Three West European customers accounted for nearly 85 percent of hard currency sales in 1987—West Germany, 16.6 billion cubic meters (bcm); France, 8.4 bcm; and Italy, 8.4 bcm.

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The Soviet Press Documents Waste

In residences . . .

Heat provided by centralized boilers is seldom measured, and a flat monthly rate is charged regardless of usage. Stories abound of overheated apartments cooled by open windows in the winter because of the lack of controls.

Soviet appliances, which reportedly consume about 5 percent of total electricity output, use 20 to 30 percent more energy than comparable Western models. This represents an extra annual expenditure of about 100,000 barrels per day of fuel.

In agriculture . . .

In the USSR, three to five times more energy is needed to produce 1 metric ton of grain, milk, or meat than in the West. Each 1-percent increase in the Soviet harvest means a 2.5-percent increase in energy use.

Farms are accused of careless storing of oil products, poor accounting practices, and insufficient energy monitoring. Farm vehicles are often filled with motor fuels using buckets, with much fuel spillage. Poor maintenance and roughshod handling reportedly cause many tractors to use 50 percent more lubricating oil than anticipated by designers.

In transportation . . .

The more fuel-efficient modes—pipeline, rail, and waterway—account for more than 90 percent of freight. Waste and inefficient use in automobile and truck transport nonetheless cut into tight supplies of crucial fuels:

- About one-fourth of all Soviet roads are unpaved, lowering fuel efficiency by about 30 percent.

- Numerous villages and regional centers are located many kilometers from the closest filling station—a large quantity of motor fuel is used simply to make the round trip.
- The pumps at some gas stations deliver only preset volumes. Customers who want to fill up must choose a higher setting than needed, so excess fuel overflows the tanks.
- Most Soviet trucks have a load capacity of 2 to 5 tons. Because many freight cargoes are less than 2 or more than 5 tons, trucks may travel underloaded or require two delivery runs.

In industry . . .

Few enterprises are even equipped to accurately measure and control energy at the point of use:

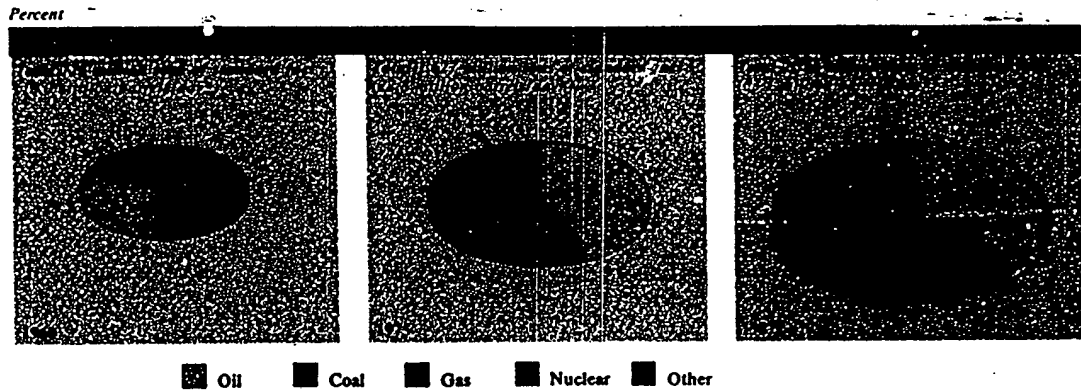
- One out of eight plants using natural gas has no meters at all. Gas suppliers, in turn, are rewarded according to volumes delivered, so they penalize customers for using less than planned amounts. Thus to maintain a cushion for when the distribution system is stretched, some customers routinely either pay for gas they never use or accept surplus deliveries and flare them.
- In a recent review of 320 factories, it was found that only 10 percent of the enterprises had developed or were implementing energy-saving measures—such as recovery of waste heat—a common practice in the West.

-
- Moscow has little flexibility to cut exports to client states. Eastern Europe depends on Soviet oil for more than 90 percent of its total oil imports and about 80 percent of its oil consumption. About 8 percent of Soviet oil exports go to Cuba and Vietnam, and about 40,000 b/d go to Afghanistan,

Angola, Ethiopia, Mozambique, Nicaragua, and South Yemen as part of economic aid. Client states have insufficient hard currency to buy oil elsewhere.

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Figure 3
USSR: Energy Production



* Oil equivalent.

Figure 4
USSR: Estimated Demand for Primary and Secondary Energy, 1987

	Oil	Natural gas	Coal	Hydro	Nuclear	Other
<i>Typical measured units</i>	624 millions tons	727 billion cubic meters	760 million tons	220 billion kilowatt hours	187 billion kilowatt hours	
<i>Million barrels per day oil equivalent</i>	12.5	11.8	6.4	1.0	0.8	0.6
<i>Million tons standard fuel</i>	893	840	460	71	61	42

Electricity production 16%	Central heat 23%	Noncentral heat 5%
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Industry 41%	Household-municipal 19%	Exports 19%
Transportation 13%	Agriculture 6%	Construction 2%

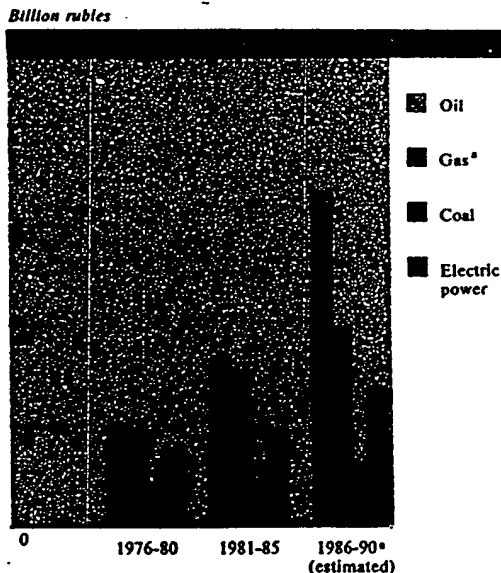
* Output by type.

* Shares of primary energy.

* Shares of final demand.

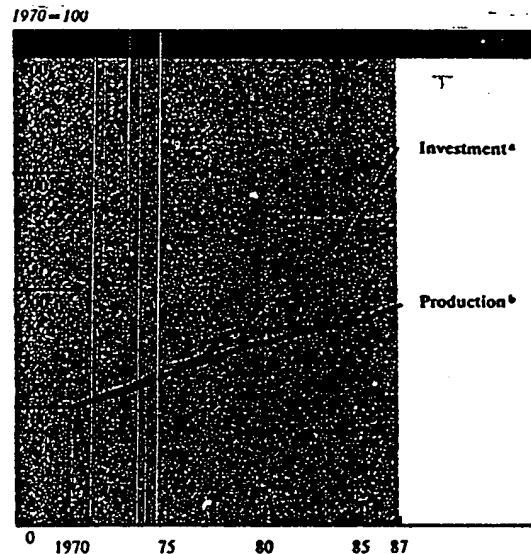
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Figure 5
USSR: Investment in Energy Production



- ^a Includes estimates of investment in gas pipelines.
- ^b Needed to keep oil production stable.

Figure 6
USSR: The Escalating Cost of Energy Production, 1970-87



- ^a Index of investment in machinery, equipment, and buildings, measured in 1984 rubles.
- ^b Index of aggregate production of oil, natural gas, coal, minor fuels, and nuclear and hydro power, measured in standard fuel units.

Feeding the Addict

Soviet primary energy production has more than tripled since 1960, reaching an alltime high of 2,366 million tons SF in 1987—slightly more than production in the United States (figure 3).¹ Over 40 percent of this output was used to generate electricity and to provide heat, while the remainder went directly to end users—principally industry, exports, and the household-municipal sector (figure 4). During 1981-85, energy output grew nearly 240 million tons SF while domestic demand grew about 230 million tons SF and export growth accounted for the balance.

¹ The composition of primary energy production has changed substantially: in 1950 nearly two-thirds of primary energy production was solid fuel—coal, peat, and fuelwood; by 1975 oil and natural gas accounted for two-thirds of primary energy production, and their share reached almost three-quarters by 1987.

In recent years these impressive increases in energy production have been achieved at very high cost. Investment in the energy sector has soared, and, more ominously, the increment of investment needed to sustain growth in production has also risen (figure 5). During 1981-85, for example, the 2.3-percent average annual increase in energy output was accomplished through a 7.5-percent annual growth in energy investment (figure 6). The share of energy investment in total investment rose from an average of 10 percent during 1976-80 to roughly 15 percent in 1987.² Energy investment now accounts for more than 40 percent of industrial investment. Tables in the appendix provide data on Soviet energy production and investment.

² If investment for gas pipeline construction, the petroleum refining industry, and minor fuels production are included, energy allocations approximate 20 percent of total investment.

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Despite Gorbachev's 1985 statement calling for freezing the share of investment for energy, the 1986-90 plan called for investment in the fuel and energy complex to grow by 35 to 40 percent—much faster than the roughly 20-percent increase of overall investment.⁷ This investment is to support an increase in energy output of about 20 percent, continuing a trend of diminishing returns to energy investment. Analysis of Soviet investment plans and production targets for 1986-90 indicates that the oil and gas industries are again the main recipients. Both development and exploration drilling in the principal oil region (West Siberia) are to double, compared with drilling during 1981-85. Investment in infrastructure to support the production effort is also slated for a big increase. The targets for gas production and gas pipeline construction suggest that investment in the gas sector during 1986-90 will probably grow by one-third.

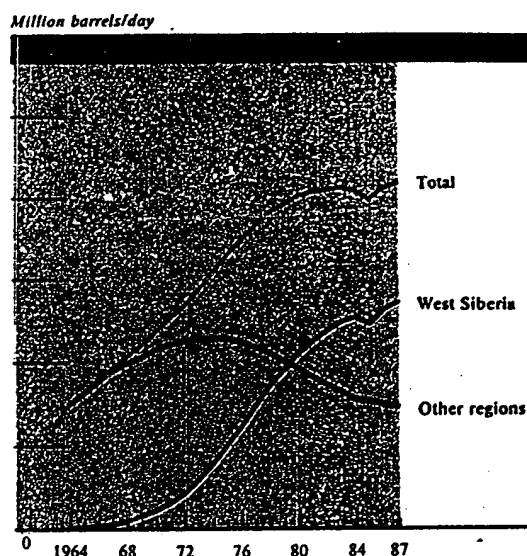
Oil: Ever More Expensive

Since 1960, Soviet oil and gas condensate production has risen from 3 million b/d to more than 12 million b/d, making the USSR the world's largest oil producer. From the mid-1950s to 1975, large, productive oilfields in the Volga-Urals region sustained production growth. Production in this region peaked in 1975, but development of prolific giant oilfields in West Siberia allowed national output to show large increases through 1980 (figure 7). During 1981-83, however, the rate of growth of Soviet oil output slowed to less than 1 percent per year. In 1984 and 1985, despite intensive efforts to stabilize oil output, national production fell roughly 100,000 and 300,000 b/d, respectively. Oil production rose in 1986 and 1987, but we believe that the USSR cannot sustain this growth for long because many of the factors responsible for the upturn are of a short-term nature.⁸

⁷ We estimate that Moscow would need to invest roughly 190 billion rubles on energy during 1986-90, an increment of about 50 billion rubles above the 1981-85 level, to reach planned goals for output.

⁸ The 1986 rise in oil production resulted from an increase in West Siberian output, realized by repairing idle wells and returning them to production. Idled wells—those needing new or repaired pumping equipment or bottom-hole cleaning—were a primary cause for oil output from West Siberia to fall for the first time in 1985. For example, the Soviet press reported that one in three wells at the supergiant Samotlor oilfield was idled by yearend 1985. In 1986, the Soviets dispatched hundreds of well-repair brigades from other parts of the country to West Siberia. The number of idled wells was reduced, and this increase in capacity, along with a sharply stepped-up pace of drilling and well completions and improved gas-lift operations at West Siberia's two largest oilfields, contributed significantly to the turnaround in oil production.

Figure 7
USSR: Regional Impact on Oil Production



Indeed, oil production leveled off in 1988 and has declined slightly in recent months.

Under current energy policy, Moscow is trying to stabilize oil output at just above 12 million b/d, even though all the factors that affect oil production are worsening and investment costs are escalating rapidly.⁹ New well flow rates are falling, well depths are increasing, the share of free-flowing (easy maintenance) wells is declining, and the importance of

⁹ Soviet sources have not stated a specific long-term goal for oil production, but several sources lead us to the conclusion that it is about 12 million b/d (600 million tons of oil and condensate). The 1984 Long-Term Energy Program, for example, called for the maintenance of oil output at "a high and stable level." When the Program was announced, oil production had been running 12.2-12.3 million b/d. Since that time, Moscow boosted investment in the oil industry by more than 4 billion rubles—a 40-percent increase—to keep oil output at the current level of 12.4 million b/d. The plan for 1989 calls for oil output of 12.6 million b/d.

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expensive offshore and high-sulfur onshore oilfields is growing. Returns to oilfield drilling have dropped sharply (figure 8). According to Vladimir Dolgikh, former party secretary for heavy industry and energy, the costs of 1 ton of new oil-producing capacity rose from 48 rubles in the mid-1970s to 88 rubles in 1985. By 1990 these costs are expected to reach 129 rubles.

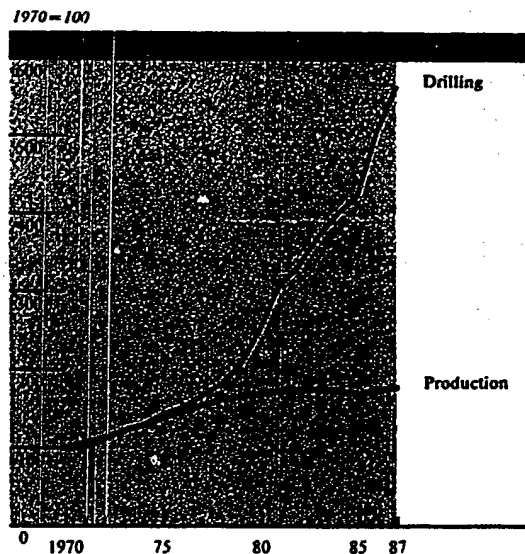
Oil now absorbs one-half of energy investment, up from one-third in 1975, and has an increasingly voracious appetite. In 1986, for example, Moscow planned to increase investment an unprecedented 30 percent while oil production was slated to grow by only 4 percent. These rising investment requirements will make it very difficult for Moscow to continue efforts to stabilize oil production while maintaining investment commitments to other energy and economic programs.

Despite worsening conditions and rising costs, the Soviets are continuing efforts to increase oil production in West Siberia. Plans for oil production show that output in West Siberia is supposed to grow by 70 million tons SF by 1990, while aggregate output from the other oil-producing regions falls by about 40 million tons SF. In total, the Soviets will replace roughly 860 million tons SF of capacity during 1986-90 because of depletion.

The Soviets are planning to step up the addition of proved reserves by doubling exploration drilling during 1986-90 and also by extensively using enhanced oil recovery (EOR) methods to continue production at depleted and low-pressure fields. Although doubling oil exploration drilling will probably improve the situation somewhat, we believe that new capacity in West Siberia will have to come from fields that are more complicated geologically, more remote, smaller, and less productive (figure 9).¹⁰ Moscow's past record

¹⁰ A major risk in a policy favoring West Siberia is that the volume and quality of oil could worsen. Soviet geologists frequently overestimate oilfield reserves and field quality, largely because of poor field delineation practices and a desire to receive bonuses for meeting plans for reserve additions. These mistakes often lead to poorly designed development schemes, increased costs, delays, and lower ultimate oil recovery. Recent press reports suggest that a debate is occurring among Soviet energy officials concerning the adequacy of reserves for future production. Moscow could find itself in a situation where substantial resources would be needed just to control a steady decline in oil production if the geologists have substantially overestimated reserves.

Figure 8
USSR: Decreasing Returns to Oilfield Drilling



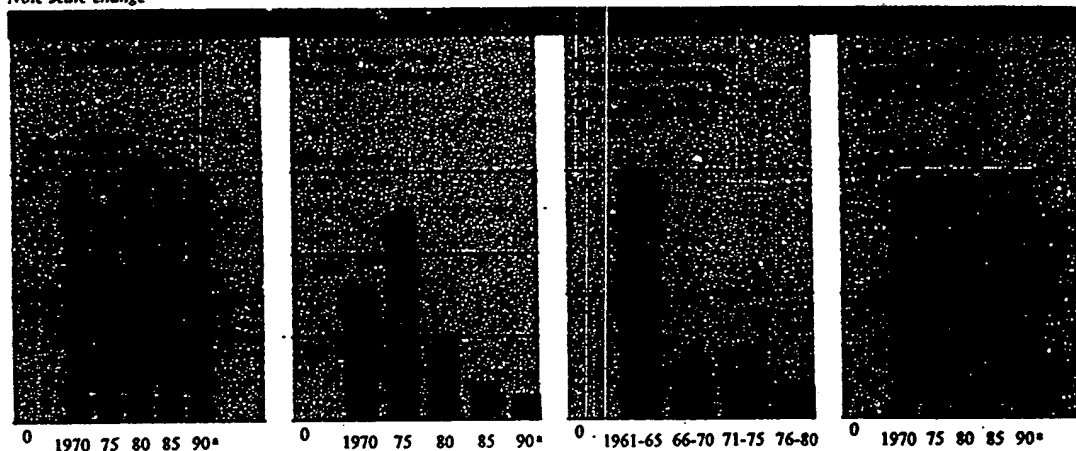
in utilizing EOR technology, furthermore, is not promising: production from EOR methods reached roughly 5 million tons of oil in 1985—only 2 million above the 1981 level of 3 million tons. For each ton of new oil-production capacity, additional drilling, equipment, and infrastructure will be needed and oil industry costs will invariably rise

By the late 1990s, oil production in West Siberia—the USSR's largest producing region—is likely to be declining. Without substantial output from a new, highly productive oil region, Soviet oil output could fall below 10 million b/d by the year 2000. The North Caspian region appears to be the most promising of all the prospective new regions

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Figure 9
USSR: Key Trends Affecting Tyumen' Oil Production

Note scale change



* Estimated.

* From Soviet statistics on availability of "explored" reserves.

The Soviets are counting on the development of the oil and gas potential of the deep, high-pressure, high-temperature formations in the North Caspian basin as the next major source of oil. But their petroleum technology is woefully inadequate for these conditions. The Soviets will need to import large volumes of Western oilfield equipment to develop this region. Even with these imports, development is likely to be slow, and production from the North Caspian in the late 1990s, under the best of circumstances, will not fully offset declines in output from the West Siberian and Volga-Urals regions.

The Soviets have been conducting exploration drilling in the Barents Sea since 1982, and our analysis indicates that it is a promising oil-bearing region. They have also begun exploration of the adjacent Kara Sea. No commercial offshore oilfield has yet been discovered, and the harsh environmental conditions—pack ice, cold temperatures, and high seas—

will necessitate a cautious and well-engineered approach to development. The Soviets have been trying to acquire Western technology and help for developing oilfields in somewhat similar conditions off Sakhalin Island since 1975 but have not yet found willing Western partners. Published Soviet analysis of the complex geology of eastern Siberia suggests that only limited oil reserves have been discovered. Development will be difficult and costly because of the distance to industrialized centers, the complexity and small size of the reservoirs, and the severe climate and terrain.

Natural Gas: Finding New Customers

Among the major fuels, only gas production has grown substantially in recent years, increasing by 66 percent between 1980 and 1987. During this period,

The Oil Production Potential of the North Caspian Basin

Recent press reports indicate that Soviet geologists believe that the North Caspian depression will become the USSR's next major oil-producing region. Some reports state that the USSR plans for annual output to exceed 1 million barrels per day by the turn of the century. Much of this optimism is derived from preliminary estimates of the oil reserves of the Tengiz oilfield, which range up to 18 billion barrels—equaling the USSR's largest oil discoveries to date.

Commercial exploitation in the North Caspian basin, however, will be difficult and expensive. Well drilling, both in the exploration and development phases, is proving difficult because of problems associated with the great depth of producing formations, abnormally high pressures, and the presence of "sour" (toxic and corrosive) gas. Western technology and equipment are needed for many operations, and the Soviets are making large purchases of hardware for the drilling and completion of wells and for processing output. However, both increased acquisition and better assimilation of Western technology are essential if exploration and development of this basin are to be accelerated.

So far, exploitation of this area has been slow. Startup of the first oil treatment plant at Tengiz is at least a year behind schedule. The press reports that releases of toxic hydrogen sulfide gases have caused fatalities. Many of the wells at Tengiz are taking three to four years to complete, compared with about six months for comparable wells in the United States (in West Siberia, wells to 2,500 meters are completed in roughly two weeks). Furthermore, one well at Tengiz blew out in 1985 and was out of control for 12 months.

gas accounted for 80 percent of the increase in primary energy. Because of the country's vast natural gas reserves and the gas industry's established record of boosting output, we believe that gas production will reach 875 bcm in 1990 and 1,100 to 1,200 bcm by the

mid-to-late 1990s. Attaining these output increases will require development at one or two new gas deposits—mainly from huge reserves in West Siberia—every five years. Such a plan appears feasible.

Maintaining steady growth in gas supply, however, will depend largely on the ability of the Soviet economy to absorb the increases that the gas industry can provide. Greater use of gas will require further expansion of the transmission, lateral, and local gas pipeline networks. Moscow must also build more storage facilities to overcome the reluctance of enterprises to rely more heavily on gas because of fears that their supply may be interrupted during peak demand periods in the winter.

Expansion of gas production thus far has largely supported one customer—the power industry. It was able to absorb 60 to 70 percent of the annual increment in gas output because a long-delayed program to substitute natural gas for fuel oil finally produced results. Over one-half of the gas used by power plants went to replace oil and low-quality coal with the remainder used by new plants. By 1986, about 40 percent of power plant fuel needs were supplied by gas.

Sustaining this effort will be increasingly difficult. Much of the gas-for-oil substitution that has already occurred has been based on the availability of power plants equipped to burn either fuel. Using more gas in the industry will mean constructing new plants, bringing gas to areas not now supplied, and eliminating delays in extending lateral pipelines to power plants currently under construction. Energy planners will be seeking gas customers outside the power industry, but no other potential customer has this industry's fuel demand or can wield the bureaucratic clout necessary to coordinate the connection to the gas distribution system. Expanding gas use in other industries will require faster construction of small, local pipelines and the use of more gas-fired equipment and appliances.

Soviet gas producers also face rising costs in the 1990s. As the center of West Siberian gas production activity shifts farther north above the Arctic Circle and encounters even more extreme environmental conditions, the investment costs per unit of new capacity will increase. Tapping these reserves will involve higher costs because of the difficult drilling, logistic, and transportation problems. For example, we estimate that investment in 1986-90 will be about one-third higher than investment in 1981-85 for obtaining an equivalent increment in gas production. In addition, the development of the West Siberian fields has required an immense gas pipeline system that, by 1990, will cost 60-70 billion rubles.

Nevertheless, we believe that the gas industry's requirements will be met because gas affords a comparatively high return to investment. Although the industry's use of labor and investment appears relatively inefficient compared with those in the West, expanding gas production will continue to be the most cost-effective way to boost energy output. Indeed, as gas met a growing share of Soviet energy needs throughout the 1980s, the gas industry absorbed a decreasing share of total Soviet investment in energy production. Moreover, the planned leveling off in gas production in the mid-to-late 1990s should drastically reduce investment requirements.

Coal: Using the Low-Quality Output From Distant Basins

Coal production from most major Soviet basins has been stagnant during much of the past decade. Production in the Donets basin—the country's largest producer of high-quality coal—is declining despite repeated efforts to maintain output. Similar prospects hold for most other basins in the European USSR, where underground mining predominates and reserves have been depleted after many years of mine operations.

The Soviets are counting on the development of selected basins in the eastern USSR—Kuznetsk, Kansk-Achinsk, and Ekibastuz—to move coal back to the forefront of energy production. But before this can occur, the Soviets must solve two key technological problems:

- *Low quality of the coal.* Most of the USSR's coal reserves are low in energy value, comprising lignites (often with high moisture content) or subbituminous coals with a high ash content. These coals require unique approaches to mining, transportation, and combustion.
- *Distance.* The major coal deposits that the Soviets want to develop are thousands of kilometers from the industries and population centers most in need of the energy. Consequently, low-cost energy transportation is essential to the viability of any coal-development scheme.

We believe that, without a large infusion of investment and research and development (R&D) resources, Moscow will not succeed in raising coal production to the targeted 950 million tons of raw coal in the year 2000 (output in 1987 was 760 million tons). The Soviets have to date made little progress in the development of the required coal-use and energy-transfer technologies—large-capacity lignite-fired boilers, coal-slurry pipelines, ultra-high-voltage (UHV) electricity transmission systems, and synfuel plants. Mastering these technologies will require carefully planned, well-executed R&D and sizable capital outlays, very little of which has been forthcoming.

Development of technologies for UHV transmission and synfuels are at a virtual standstill; the lignite-fired boilers are being built at a snail's pace, and those at Kansk-Achinsk are only now being tested on a commercial scale; the Soviet R&D program for coal-slurry pipeline technology went virtually nowhere, and Moscow was forced to purchase Italian technology for the construction of the prototype slurry pipeline in the Kuznetsk coal basin. Failure to fully develop the Kansk-Achinsk basin according to plans and less-than-stellar growth at the Kuznetsk and Ekibastuz basins would probably result in coal production hovering around 800 million tons for the remainder of the century.

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Problems in Burning Low-Quality Coal From Siberia and Kazakhstan

The low heating value of low-quality coals (3.3 to 3.5 million kilocalories per metric ton) make them uneconomical to ship more than 1,000 to 1,500 kilometers. They must be burned in mine-mouth power plants with the electricity transmitted over long-distance powerlines to consumers. The low heating value also means that much more coal must be burned to produce the same amount of electric power, increasing the requirements for coal mining and handling. The heating value tends to vary, making it difficult to control the combustion process well enough to prevent boiler fouling and reduce pollution. The high moisture content (30 to 40 percent) of Kansk-Achinsk coal increases handling problems and robs the coal of some of its heating value as the water is vaporized during combustion.

The combustion of such massive amounts of coal produces correspondingly large quantities of ash that must be cleaned from the flue gases before they can be discharged into the air, increasing the burden on pollution-control equipment. The ash in Kansk-Achinsk coal contains large amounts of alkali metals that melt during combustion and foul the heat-exchange surfaces of boilers. Power plant boilers must be designed to prevent fouling by using tall boiler compartments, soot-removal systems, and carefully controlled combustion temperatures, all of which increase their cost. The very high ash content of Ekibastuz coal (40 to 60 percent) makes it abrasive, causing rapid wear and frequent maintenance of all coal-handling equipment—pulverizers, boiler feed tubes, and the inside surfaces of the boiler itself.

Electricity: Revitalizing the Nuclear Energy Program
Expansion possibilities for hydroelectric power in the European USSR are now limited because most water resources are already exploited. Hydroelectric plants in the European USSR are viewed as the primary suppliers of electricity during peak daily and seasonal demand. There are vast reserves in eastern

Siberia, but tapping these rivers will not be economical until these remote regions become developed or until breakthroughs are achieved in the technology and cost-cutting of very-long-distance power transmission. (

Nuclear energy is scheduled to grow at a rapid rate so that its share of total energy would expand from less than 3 percent in 1987 to more than 10 percent by the year 2000. This would require the nuclear program to grow from 34,600 megawatts, which produced 187 billion kilowatt-hours in 1987, to about 160,000 megawatts in 2000, slated to produce over 1 trillion kilowatt-hours. (

Before the Chernobyl' accident added new complexities to already ambitious goals, the nuclear program had been dogged by shortfalls of material and equipment, lack of skilled labor, holdups of design approval, and construction delays. The combination of a public reaction to the accident and the new freedom to publicize even some opposing views in the Soviet media made an antinuclear lobby possible. The Soviet antinuclear lobby—loosely organized, geographically dispersed, and a cross section of the public and elite—has successfully challenged the USSR's nuclear power program, contributing to delays and even cutbacks in plant construction.

A leading Soviet nuclear scientist judged that the nuclear power industry has been set back by "two five-year plans" (1991-95 and 1996-2000). We estimate that the construction cancellations resulting from the regime's response to the antinuclear lobby will undercut plans for electricity supply in the mid-to-late 1990s. Together with the much larger impact of standard bottlenecks, the expansion of nuclear power will be held to about 80,000 megawatts, which should generate about 500 billion kilowatt-hours in the year 2000. (

Getting the nuclear power program back on track will require increased spending on safety and an intensive public education effort to regain acceptance of nuclear energy. Soviet specialists are still assessing the

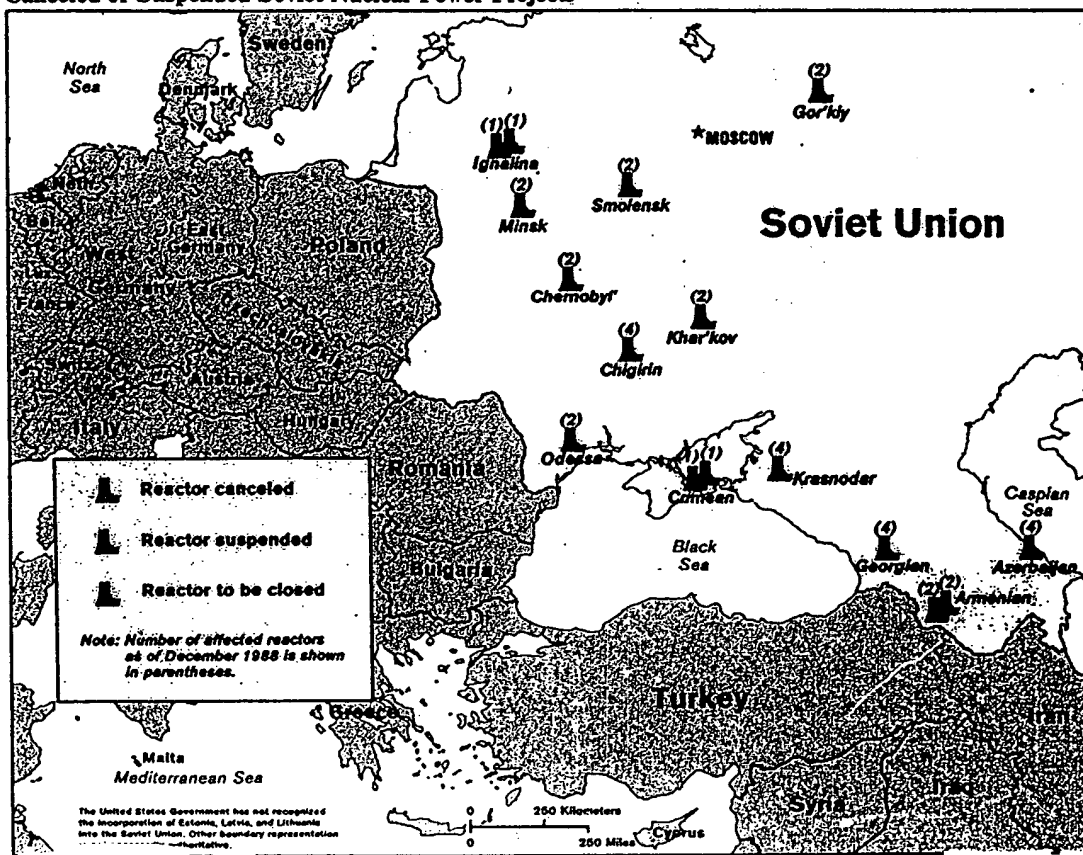
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The Nuclear Power Controversy

Moscow needs the energy contribution from nuclear power so that production of increasingly costly fossil fuels can be reduced. Citizen opposition to nuclear energy, however, has become more vocal and effective under glasnost. Critics have broadened their attacks on nuclear energy projects from initial focus on cancellation of construction at Chernobyl-type plants to challenges about the suitability of locations for future plants of nearly all types. Recently, protesters for the first time won a promise that an operating

facility—the Armenian nuclear power plant—would be closed. The regime cannot afford to give up on nuclear energy by yielding to all of the demands of the critics, nor can Moscow risk an unacceptable level of social unrest by pushing nuclear energy projects and ignoring local objections. This controversy will influence decisions during a key period of energy policy formulation and will probably affect allocations to new nuclear construction and safety upgrades as well as how much to rely on fossil fuels

Canceled or Suspended Soviet Nuclear Power Projects



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costs of safety upgrades. Although nuclear energy remains an economical source for electricity generation, many influential Soviet citizens are critical of the nuclear industry, making an uphill battle for public support likely.

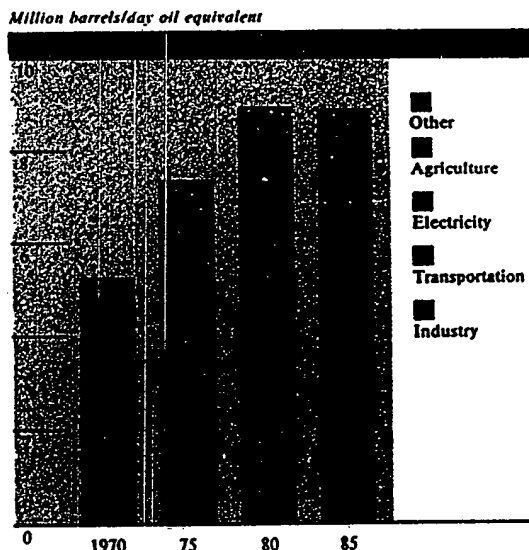
Interfuel Substitution: Stretching Oil Supplies

Since the mid-1970s, the Soviets have considered interfuel substitution as one of their most important tools in reducing oil use. The initial efforts aimed solely at switching power plants from fuel oil to natural gas failed, and power plant oil use continued to grow. By 1985, however, power industry oil use declined nearly 400,000 b/d, compared with 1980 consumption. Such progress in gas-for-oil substitution has enabled the Soviets to hold their total oil consumption constant since 1981, even though demand for light products has been growing (figure 10).

The Soviets now want to expand this program to substitute gas, coal, and nuclear energy for increasingly expensive oil. The Long-Term Energy Program calls for continued substitution of natural gas for some of the heavier oil products, mainly fuel oil. By the year 2000, increased output from nuclear plants is expected to help stop growth in the use of fossil fuels. While success in meeting these goals would not greatly increase the overall energy efficiency of the economy, it could, in the short run, allow Moscow to increase supplies of light petroleum products without a proportionate increase in oil output. In the longer run, success in interfuel substitution would reduce demand for oil, allowing Moscow to shift resources to other energy and economic programs

Meeting interfuel substitution goals for the next decade requires investment outlays to connect power plants to gas networks, construct nuclear power plants, build coal-cleaning plants to improve coal quality, expand gas distribution and storage facilities, and upgrade oil refineries to increase the yield of light products. Projects are under way in every area, including expansion of catalytic cracking capacity at refineries. Most of these projects would offer higher returns to investment than would continued efforts to expand oil output. For example, Soviet petroleum experts estimate that increasing production of light products by 7 percent from new cracking capacity

Figure 10
USSR: Estimated Oil Use, 1970-85



would cost 375 million rubles. Achieving this increase from more oil output and primary refining, on the other hand, would reportedly cost an estimated 6 billion rubles

Conservation: Modernizing and Motivating Energy Consumers

The Soviets have pursued a production-oriented energy policy to meet growing demand and have made few efforts to stretch available energy supplies. Energy conservation targets have been specifically included in five-year plans at least since 1971-75, but goals have been modest. In the 1981-85 plan, for example, the

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conservation goal was to save 146 million tons SF—roughly 7 percent of planned total energy supply in 1985—but Soviet consumers fell short of the target for savings by 30 percent. Investment allocations have slighted energy conservation, and the Soviet economy is presently ill prepared to make rapid progress in conservation:¹¹

- Not much conservation equipment is produced in the USSR. A nationwide program of intensive energy conservation would require either major equipment imports or the establishment of new plants to produce such equipment.
- Large-scale energy conservation requires thousands of small-scale actions that cannot be managed from Moscow because measures are often plant-specific, relying heavily on individual initiative.
- Retention of obsolete equipment makes conservation difficult. Retirement rates have been especially low in some of the most energy-intensive industries (electricity, ferrous metals, machine building, and chemicals).

Moscow's current plan for energy conservation reveals continued low expectations. The conservation target for 1986-90 of 125-140 million tons SF is set lower than the target for 1981-85. Three-quarters of this lower target is to be achieved by introducing new technologies in energy-intensive industries, retiring obsolete equipment, and putting to work some of the heat energy that now goes up smokestacks at power plants and factories. While this program would require major investment, returns would be substantially higher than those of new investment in energy production. Soviet writers repeatedly stress that the investment required to boost net energy production is

¹¹ Shortcomings in the measurement of the USSR's energy efficiency also contribute to the lack of priority for conservation. Economic growth is calculated in terms of national income (NI), instead of the GNP measure widely used in the West. Because NI accounting overstates economic activity and therefore growth, Soviet assessment of energy use per increment of NI erroneously shows more energy efficiency than what actually occurred.

USSR: Fuel Conservation Targets, 1986-90

	Share (percent) 100
<i>Savings</i>	
<i>Install new energy-efficient technology</i>	50
<i>Reduce transportation losses and use</i>	20
<i>Replace obsolete equipment</i>	15
<i>Reclaim waste heat</i>	10
<i>Make general reductions (belt-tightening)</i>	5

two to three times as great as that needed to conserve an equivalent amount of energy.

Success with these investment-intensive conservation strategies ultimately depends on progress in Gorbachev's modernization program, which is to provide industry with energy-efficient machinery and equipment as well as to supply the energy industries with increasingly sophisticated hardware, much of which is now imported.¹² In the short run, however, modernization will probably add to the energy bill because of its emphasis on growth of the energy-intensive machine-building and metalworking sector. Before the economy can benefit from new energy-saving technology, it must pass through a transition period when the economy uses more energy to increase output of more efficient machinery.

¹² According to Soviet energy specialists, a long-term conservation goal is to attain the levels of efficiency reached in the West. For example, to match the efficiency of the Japanese economy, Moscow would need to cut energy use by 40 percent. Improving Soviet energy use to the levels currently attained in the United States and in OECD countries would require a 30-percent cut in energy demand.

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As modernization results in industrial processes that are more productive and less resource intensive, energy will be saved. Furthermore, sizable energy savings could be accomplished, as they were in the West, by modernization that shifts the composition of industrial output to industries that use less energy. But this is proceeding slowly, and even aggressive investment in energy-saving equipment would take time to produce results.

The Soviets also have opportunities to improve energy efficiency by means that require almost no additional investment. Such means include turning off equipment when not in use, better monitoring and control of energy use, and improvements in management of industry that focus on maximum use of production capacity and avoidance of frequent stopping and starting of machinery. Implementing these nearly cost-free measures requires more monitoring equipment, breaking of bottlenecks in supply of raw materials and parts that prevent efficient utilization of machinery, and additional skilled workers.

The effectiveness of these measures, however, depends mainly on whether the Soviets can introduce real incentives for conservation. Soviet officials admit that large price increases are needed to "destroy the illusion" that energy resources are cheap and inexhaustible and to create the necessary incentives for the design, production, and application of resource-saving equipment [

Energy prices will rise by 90 percent" as part of a wholesale price reform that will begin in 1990. In 1989 enterprises are to be operating on a self-financing basis, wherein they are to cover all costs from their own revenues

These measures will help, but they are unlikely to yield sizable and sustained gains in conservation or to provide a basis for economically rational choices among alternative fuels. New fixed prices will be set administratively, in little relation to demand, and will increasingly diverge from costs over time. Despite self-financing, enterprises—facing little competition—will be able to pass on higher costs to their

customers. Sharp increases in energy prices in 1967 and 1982 provided only small and transitory gains in conservation. Soviet economic reforms do not promise to go far enough during the next five years to establish the preconditions for real conservation—flexible prices and a competitive market.

Reconciling Means and Ends

Moscow's Long-Term Energy Program and other plan documents call for energy supplies to increase from 2.2 billion tons SF in 1985 to about 3.3 billion tons in the year 2000. Gas and nuclear energy are to account for more than one-half of energy production in 2000, while oil's share is expected to drop to one-quarter. All of these increases are to be accomplished with only a slight increase in energy's share of investment. Finally, the Long-Term Energy Program stepped up conservation targets, calling for energy savings to cut energy demand in 2000 by as much as 15 percent.

Although the Soviets have yet to come to grips with this problem, maintaining this largely production-oriented energy policy would force Moscow to make difficult decisions in the 1990s to balance the investment needs of the energy sector with other important programs such as the campaigns to modernize industry and improve consumer welfare. Indeed, energy production already is running behind planned levels (figure 11). To roughly sketch the trade-offs involved, we contrast two extreme investment scenarios for the 1990s—letting investment rise to ensure that energy goals are attained and, alternatively, holding energy's share of investment constant, even at the risk of failure to meet production targets. Both scenarios should be considered crude benchmarks because they do not account for policy corrections that Moscow would most likely make during the 1990s, nor do they reflect the changes in overall economic growth that would occur if either scenario were implemented.

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The Long-Term Energy Program

Moscow's efforts to deal with new challenges in energy policy are reflected in the Long-Term Energy Program, published in 1984, which defined the USSR's energy goals to the year 2000. No aspect of the energy sector was neglected in this policy statement, which appeared to be a compromise among the various advocates of conservation, interfuel substitution, and energy-producing industries.

The Program's goals for oil production were stated in vague phrases—such as “securing a stable, high level of oil output” and “an increase in liquid fuel”—that ensured continued priority for resource allocation, but are difficult to translate into output targets. Natural gas was touted as the growth fuel until the mid-1990s, when output was scheduled to plateau at an unspecified maximum. Nuclear energy, coal, and hydro (in a reduced role) were slated to meet all growth in energy demand beginning in the late 1990s. Conservation targets, although significant, seemed to imply that most savings would come in the late 1990s rather than growing throughout the period. Fuel substitution was to play a part in the transitions from oil to gas and later from gas to coal.

USSR: Goals for Energy Supply, Year 2000

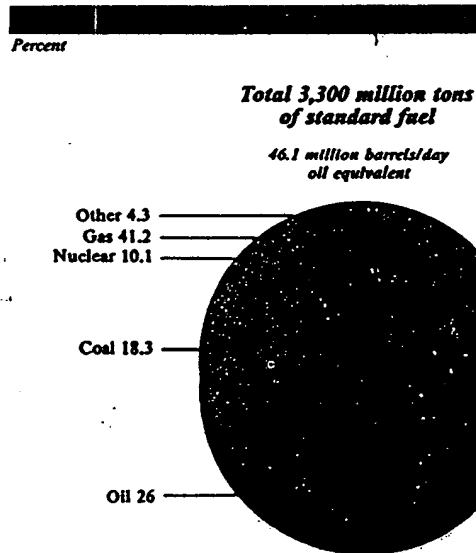
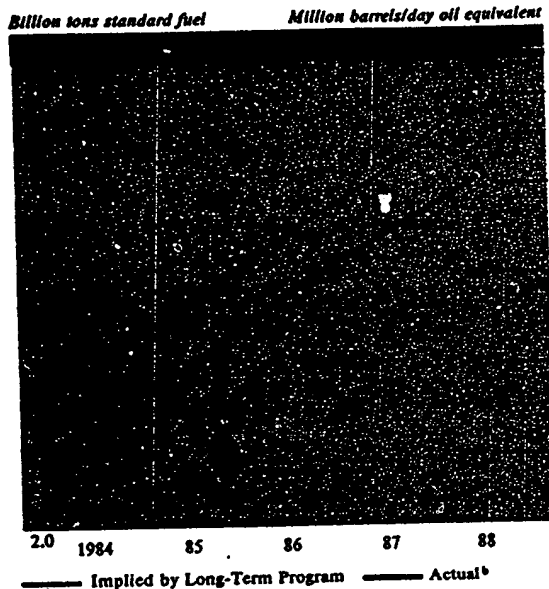


Figure 11
USSR: Progress Toward Long-Term
Energy Program Goals^a



^a The Long-Term Energy Program did not indicate goals for this period but implied these targets if goals for later years were to be reached.
^b Output for 1988 is estimated.

In the first scenario, we assume that Soviet policymakers allocate whatever investment is necessary to achieve the 40-percent increase in energy production scheduled between now and the year 2000. Moreover, it is assumed that they provide all investment necessary to meet the Energy Program goal of keeping oil production from falling below current levels. Because of the increasing costs of new energy—increments to supply must offset depletion of existing production capacity, and new energy sources will cost more to develop—energy's demand for investment would explode (figure 12). The share of investment needed to meet energy production goals would rise from about

15 percent in 1987 to more than one-third in 2000.¹¹ If this policy were actually implemented, industrial modernization goals would be largely forfeited and overall economic growth would, at best, stagnate and probably turn negative.

In the second scenario, we assume that Soviet policymakers follow through on the promise to hold energy's share of investment essentially constant between now and the year 2000, thereby enabling sustained growth of investment for other programs such as modernization and consumer welfare. Under our assumptions, annual growth in energy investment would fall from 7.3 percent in the 1980s to less than 3 percent in the 1990s. In this event, energy production probably would actually decline between now and 2000—by as much as one-half—if the Soviets stubbornly pursued oil production targets and did not reallocate investment toward more cost-effective natural gas. Declining energy production would force rationing, and severe energy shortages would stall economic growth.

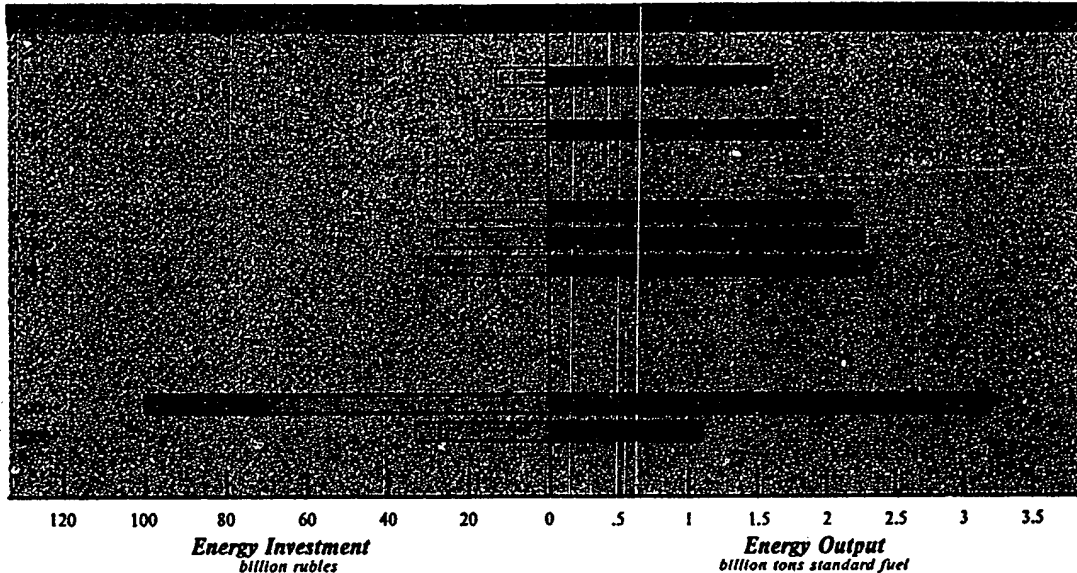
Changing Energy Policy

The enormous investment burden of sustaining energy production and the poor prospects for conservation are likely to push the Soviets to formulate a new energy

¹¹ Investment requirements are rough estimates derived from the historical relationship between energy production and investment and projected to the year 2000. The projections are based on the estimate of investment needed for new energy production capacity during 1991-95. The estimates include allowances for investment needed to compensate for future depletion of production capacity—claiming up to 40 percent of these additions.

¹² We used the economic baseline scenario that maintained current trends in the productivity and allocation of labor and capital. This baseline shows annual economic growth averaging 1.5 to 2 percent during 1986-2000, with growth in total investment averaging about 2 percent.

Figure 12
USSR: The Energy Program's Dilemma—
Staggering Growth of Investment or Devastating Cuts in Production



- Projection if Moscow opts to spend whatever is needed to satisfy energy demand.
- Projection if Moscow tried to keep energy's share of investment constant.

policy for the 1990s. So far the Gorbachev regime has endorsed, with few changes, the Brezhnev-era energy goals for the remainder of the century—broadly mandating both conservation and production. Nevertheless, Gorbachev has indicated a firm intention to emphasize conservation and other demand-management strategies for energy and other raw materials. His speeches reveal understanding of the link between such strategies and the need to conserve scarce investment resources. Senior Soviet officials—including, most recently, the Minister of the Petroleum Industry—also have highlighted the impending crunch in the 1990s.

On the basis of these and other such statements, we believe that energy policy will be revised to limit energy's growing share of investment, further shift energy production away from oil and toward more

abundant natural gas, and moderate energy demand through fuel substitution and conservation. Moscow's policy—reflecting a growing consensus among Soviet energy experts—will probably endorse the following kinds of initiatives:

- Cut costs by retreating from the earlier goal to keep oil output at a "high and stable level." For example, a reduction of 10 to 15 percent in crude output could permit substantial reductions in oil industry investment in the 1990s—by several tens of billions of rubles. In fact, if Moscow succeeds with programs now in place to reduce fuel oil use and process "saved" fuel oil into light products, the Soviets could lower oil production and still meet domestic demand and export requirements.

Gorbachev's Personal Mark on Energy Policy

Thus far, Gorbachev has taken a middle ground between endorsing much of the energy policy choices of the Brezhnev era while installing new people in the key energy management positions. An early statement of policy in the so-called science and technology speech in May 1985 lent support for Brezhnev's concentration on energy production, but also expressed concern about the investment cost of the West Siberian oil and natural gas development and the hope to reduce this burden with improvements in the technology of energy use.

Various speeches have made it clear that Gorbachev views conservation of energy as the key to long-term goals of improved economic efficiency. He has quoted those Soviet energy experts whose studies have concluded that it would cost the USSR several times less to save oil and gas than it would to produce these fuels. Moreover, Gorbachev links gains in conservation directly to a reduction in energy's claim on scarce investment resources.

During his first year as General Secretary, Gorbachev highlighted his views on energy with a much publicized trip to West Siberia. He used the occasion to affirm the continued importance of the oil and natural gas production in West Siberia to the country's

total energy program. Gorbachev also reiterated the theme that, to justify large investments, West Siberian energy must generate high yields.

Gorbachev's speech to the 1987 June plenum, outlining the scope of reform, covered the role of prices. He called for a major price revision, raising the prices of fuels and raw materials relative to those for manufactured goods. In the process, most subsidies were to be eliminated. For energy, however, reform of the price-setting mechanism was put off; these prices would continue to be centrally set.

The only far-reaching change that Gorbachev has made in energy policy has been in the personnel department. All of the ministers in the major energy production bureaucracies have been replaced, and several new organizations were activated to cope with changes in nuclear energy (Ministry of Atomic Energy and a State Committee for Nuclear Safety) and in oversight of energy technology development and the resolution of intraministerial conflicts (the Fuel and Energy Bureau). This new team has yet to distinguish itself from its predecessor—new policy is lacking.

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- Sustain growth in natural gas production to the end of the century, instead of allowing gas production to level off in the mid-1990s. Gas would then account for more than 70 percent of the likely increase in energy supplies in the 1990s. The success of a policy to rely more heavily on gas depends on keeping down costs for production and transportation while stepping up efforts to convert users from fuel oil to gas. Continued growth in gas output will be necessary until nuclear energy and coal achieve expansion targets.
 - Overcome technical hurdles in burning and transporting low-quality coal and postpone large increases in coal output until coal can be efficiently processed.
 - Reestablish a consensus that nuclear energy is safe, reliable, and cost effective. Officials will probably need to move in several directions: upgrading safety, confronting vocal critics, and educating the public on risks and benefits of nuclear power.

- Stress energy conservation without making those changes in incentives or investment policy needed to deliver real near-term gains. Despite Gorbachev's admonitions, most Soviet energy specialists continue to look to the substitution of gas for oil as the main demand-management tool. They consider industrial modernization, which eventually will yield more efficient machinery and equipment, as the source of substantial conservation gains.

Implications for the 1990s: A Difficult Decade Under Any Conditions

Although a revised energy program would mitigate Moscow's investment-production bind, it will not come anywhere close to solving the problem. The new initiatives might enable the Soviets to meet energy production targets for the year 2000, but energy's share of investment would still rise enough to cripple the industrial modernization and consumer goods programs—Gorbachev's top economic priorities. Under the best of circumstances, therefore, we expect either energy shortfalls or energy's investment demands to hold down annual economic growth. In effect, Gorbachev can avoid an energy constraint only by failing miserably in other areas of his economic revitalization program.

The new initiatives, moreover, might not all pan out because the transition to the new energy regime would have to be extraordinarily well timed. Deemphasizing coal development might stall research at the current stage, while putting the nuclear program back on track could precipitate social unrest in regions scheduled for new nuclear power plants. The decline in output from older oilfields would have to be moderated until production from the North Caspian starts to accelerate. Expanded refinery capacity to produce light products would have to be in place before fuel oil—replaced by natural gas—could be processed, thereby reducing net oil use by the domestic economy. Energy exports could not grow in volume unless domestic oil demand is curbed, because nearly all increased gas output would be needed by the domestic economy.

While gains in energy conservation theoretically provide an escape from this "catch-22" situation, achieving real progress in conservation, however, would force Soviet leaders to make radical changes in the economic system and, as in the West, to accept a long, disruptive transition period:

- The Soviets would have to give consumers real incentives to save energy. This would entail eliminating subsidies, raising energy prices substantially for both industrial users and the population, and ensuring price flexibility to reflect changing patterns of demand and extraction costs. At the same time, planners would have to abandon the system of "norms" and allow enterprises to choose energy supplies on the basis of prices and costs. The Soviets plan to decentralize control over some economic activity, but this program is moving forward slowly and, in any case, evidently does not yet extend to the energy sector. In 1989, centralized energy distribution will cover 100 percent of oil output and 90 percent of natural gas production.
- The Soviets would have to create new industries to produce equipment to monitor and control energy use. (When the oil crisis of the 1970s hit, Western industries producing energy-efficient equipment already existed and were able to expand.)

Despite Western economic incentives and supporting industries, energy efficiency did not improve much until three to four years after the oil price shocks. The slow pace of economic reform and industrial deficiencies virtually rule out major Soviet conservation gains in the 1990s.

In the absence of a sudden, unanticipated, large oil discovery or a sharp increase in world energy prices—each highly unlikely—the Soviets thus face a seemingly impossible energy dilemma in the 1990s. We believe that Moscow, confronted with a set of equally unpalatable choices, will pursue half measures to navigate the energy dilemma.

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Coping With Disruptions in Domestic Energy Supplies
Soviet energy supplies will be tight regardless of how energy policy is reformulated. Rationing, "brown-outs," and other consequences of strains in the energy sector that we have witnessed during the past decade are likely to continue, and possibly intensify:

- Whether the Soviets can meet growing demand for electricity supplies depends crucially on progress in the coal and nuclear industries. The Soviets will be hard pressed to offset declines in European coal with Siberian coal, and efforts to do so could well tax rail transport and aggravate growing popular ecological consciousness. Nuclear power presents even greater concerns, yet the Soviets have little choice but to proceed. They are likely to make frequent tactical policy adjustments as they navigate technical, investment, and social hurdles, and they will probably have to live with curtailing electricity to key customers, including Eastern Europe, as well as with social unrest.
- Natural gas looks like the answer, but this industry will probably be strapped to shoulder more of the burden rapidly enough to accommodate declines elsewhere. Gas distribution will continue to be the weak link—in particular, pipeline turbines. Industry must supply turbines to an expanding network, replace hundreds of aging compressors installed during the 1970s, and handle a growing maintenance burden. If gas distribution is disrupted, major consumers will attempt to switch back to fuel oil. Bottlenecks in moving gas would then endanger an already fragile balance between oil supply and demand. Moreover, disruptions to gas supply will risk stranding key industrial or even household users, forcing authorities to make tough domestic allocation decisions or to curtail exports.

During the 1990s, Moscow also will face considerable technical and administrative challenges in carefully managing a gradual decline in oil production. Moscow would probably need to cut oil production in the Volga-Urals and Azerbaijan fields and become more selective about high-cost fields in West Siberia in order to gain potential investment savings of billions of rubles. Such cutbacks will be difficult to control, so both the volume of the production cut and the amount

of investment savings will be problematic. Moreover, the impact of the cuts would depend on the pace at which they could be offset by new fields, particularly the North Caspian basin. If either of these programs fails, Moscow will be faced with very unpalatable alternatives—accepting a precipitous decline in oil production or mounting a crash investment program to restore production. Any unduly large decline in oil production would reverberate throughout the economy—particularly for transportation and agriculture, consumers of light products—and would likewise threaten hard currency earnings.

Finally, the energy sector could well become the Achilles' heel of Gorbachev's entire economic program. An almost certain rise in energy's share of investment will undermine goals for economic growth and improvement in consumer welfare, thereby precipitating bitter disputes in the 1990s. Moreover, bottlenecks in energy production or in the transition to a new energy policy are likely to tempt policymakers to return to their earlier roles as strong central planners, undermining—or at least distorting—Gorbachev's reform agenda.

Diminish the Critical Role of Oil in Energy Exports
The Soviets will probably try to substitute gas for oil in their energy exports to the West and Eastern Europe:

- We expect overall West European use of Soviet gas to increase from about 15 percent in 1987 to 20 percent of total consumption in the year 2000. West European gas demand is likely to grow at an annual rate of only 1 to 2 percent in the 1990s. If, however, environmental concerns or a move away from nuclear power induce West European countries to rescind the 1975 prohibition against use of gas for electricity generation, demand for gas could increase as much as 20 to 30 bcm above current estimates for the year 2000. The Soviet share of the West European market will depend on capacity available in gas pipelines, gas contracts in force, and in the effectiveness of competition from Norway, the Netherlands, and Algeria.

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- Eastern Europe is willing to accept more natural gas as a partial substitute for increased oil deliveries, but it is resisting Soviet demands that it share the costs of natural gas development—especially the construction of a new gas trunkline from Yamburg to Eastern Europe.¹⁴ East European demand for natural gas, moreover, will be constrained by the pace with which industry can be converted from oil and coal to gas, which in turn will be held down by East European economic problems.
- The Soviets will reap small gains by reducing oil export commitments to Cuba and Vietnam. By the late 1990s, a Soviet-designed nuclear power plant in Cuba should replace 30 thousand b/d of fuel oil, while exports to Vietnam—now running at 40 thousand b/d—will probably decline after implementation of a joint venture with Hanoi to develop Vietnam's offshore oil industry.
- Borrow more from the West. Although reluctant to increase hard currency debt, Moscow's credit standing would probably not suffer from an increase in debt of \$10 to \$20 billion.¹⁵ Such a solution, however, would provide, at best, a temporary respite, inasmuch as it increases the need for future hard currency export earnings.
- Make do with less imports—gambling that modernization of the Soviet economy reduces the need for Western imports and accepting the likely slowdown in import-dependent industries and agriculture.

Each additional billion dollars of hard currency obtained from other sources could enable Moscow to reduce oil exports some 150,000 b/d, at \$17 to \$18 per barrel or 10 percent of the current hard currency oil export level.

The success of these efforts depends crucially on Moscow's ability to wean client states from oil without precipitating economic disruption and to develop a range of viable substitutes for oil as the prop of Soviet hard currency earnings. The fragile economies of Eastern Europe—currently consuming 1.6 million b/d of Soviet oil—would be undermined by an abrupt decline in deliveries, probably forcing the Soviets to maintain exports close to current levels through the end of the century.

Oil will not be replaced as a hard currency earner, but a combination of initiatives could reduce the pressure to maintain oil exports. Moscow could:

- Increase nonenergy exports—in part, by promoting joint ventures with Western firms that improve the competitiveness of Soviet products. We estimate that annual hard currency earnings from nonenergy exports may increase as much as \$3 billion in the early 1990s. Earnings from arms sales are also likely to register only modest growth, mainly because low oil prices will continue to stifle repayment of Middle Eastern arms debt to the USSR.

Produce Energy More Efficiently: Import More Western Technology

The Soviets will probably want to rely more heavily on Western supplies of equipment and technology for energy production—even with a successful demand-management program. Useful and, in some cases, crucial imports would include:

- Western large-diameter pipe and heavy-duty pipelayers for laying the major transcontinental gas trunklines, essential to continued expansion of gas production.
- Western drilling, well-completion, and processing equipment for developing the "sour" oilfields of the North Caspian, necessary if Moscow is to have any hope of meeting its production goals for this region.
- Western energy-efficient equipment for industry and, particularly, instrumentation to monitor and control energy use.

Paying for increased imports, of course, potentially conflicts with the goal of reducing oil production and oil exports. This dilemma illustrates the Soviets' energy policy treadmill—they need more energy today in order to make do with less tomorrow.

¹⁴ See DI Intelligence Assessment SOV 88-10014X, April 1988. USSR: Coping With the Decline in Hard Currency Revenues.

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Appendix

Data on Energy Production
and InvestmentTable 1
USSR: Energy Production

	1960	1970	1975	1980	1985	1987
<i>Million Metric Tons Standard Fuel</i>						
Total production	725.6	1,276.3	1,626.5	1,963.5	2,203.3	2,366.5
Of which:						
Oil	302.3	502.4	701.9	862.3	851.3	892.6
Natural gas	65.3	233.6	342.6	513.9	742.9	840.1
Coal	273.2	432.6	471.6	456.8	439.8	459.7
Nuclear		1.3	6.9	23.9	54.4	60.8
Hydro	23.8	45.5	42.8	60.4	70.1	71.5
<i>"Natural" Units of Production</i>						
Oil						
Million metric tons	211.4	353.0	490.8	603.0	595.0	624.0
Million b/doe*	4.2	7.1	9.8	12.0	11.9	12.5
Natural gas						
Billion cubic meters	54.4	198.0	289.0	435.0	643.0	727.0
Raw Coal						
Million metric tons	373.1	624.0	701.0	716.0	726.0	760.0
Nuclear						
Billion kilowatt-hours	NEGL	3.5	20.2	72.9	167.0	187.0
Hydro						
Billion kilowatt-hours	50.9	124.0	126.0	184.0	215.0	220.0

* Barrels per day oil equivalent.

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Table 2
USSR: Energy Investment *

Billion 1984 rubles

	1976-80	1981-85	1980	1981	1982	1983	1984	1985	1986 ^b	1987 ^b
Total energy	75.7	108.9	17.6	19.0	20.3	21.3	22.9	25.4	27.4	30.1
Oil	29.3	50.3	7.5	8.9	9.6	10.0	10.3	11.5	13.1	14.6
Natural gas	11.3	15.9	2.3	2.3	2.6	3.1	3.7	4.2	4.5	5.0
Coal	11.4	13.5	2.4	2.4	2.7	2.7	2.8	2.9	3.0	3.3
Electric power	23.7	29.2	5.4	5.4	5.4	5.5	6.1	6.8	6.8	7.2

* Excludes investment in pipelines for oil and natural gas, oil refining, and minor fuels (peat, oil shale, and fuelwood) production. Data for 1976-85 revised to reflect "new" 1984 prices and accounting changes as shown in 1986 *Narodnoye khozyaystvo SSSR*.

^b Only data for total investment supplied; components are estimated.

Table 3
USSR: Annual Growth in Energy Investment *

Percent

	1976-80	1981-85	1980	1981	1982	1983	1984	1985	1986 ^b	1987 ^b
Total energy	5.9	7.5	8.9	8.0	6.8	4.9	7.5	10.9	7.9	9.9
Oil	10.4	11.4	9.3	18.7	7.9	4.2	3.0	11.7	13.9	11.5
Natural gas	6.6	7.1	0	0	13.0	19.2	19.4	13.5	7.1	11.1
Coal	2.9	3.4	4.3	0	12.3	0	3.7	3.6	3.4	10.0
Electric power	2.6	4.3	10.2	0	0	1.9	10.9	11.5	0	5.9

* Excludes investment in pipelines for oil and natural gas, oil refining, and minor fuels (peat, oil shale, and fuelwood) production. Data for 1976-85 revised to reflect "new" 1984 prices and accounting changes as shown in 1986 *Narodnoye khozyaystvo SSSR*.

^b Only data for total investment supplied; components are estimated.

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Table 4
USSR: Energy's Share of Investment: Industry Alone and Total *

Percent

	1976-80	1981-85	1980	1985	1986 ^b	1987 ^b
Total investment	10.5	12.9	11.7	14.2	14.1	14.7
Industry	30.1	36.2	33.0	38.8	38.6	40.1

* Excludes investment in pipelines for oil and natural gas, oil refining, and minor fuels (peat, oil shale, and fuelwood) production. Data for 1976-85 revised to reflect "new" 1984 prices and accounting changes as shown in 1986 *Narodnoye khozyaystvo SSSR*.

^b Only data for total investment supplied; components are estimated.

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